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INFLUENCE OF SITE FACTORS IN BOMBAX PLANTATIONS

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ABSTRACT

As noted in Working Plan Reports, ***Bombax ceiba L.*** (Bombax) does not attain sufficient height by the rotation age of 25 years in many plantations. The slow height growth may be due to climatic, physiographic, biotic and soil factors which constitute the environment (site) of tree stand. The present project was taken up to ascertain whether stunting is due to site factors, especially soil.

Literature is scanty regarding investigations on influence of site factors in Bombax plantations. One hundred and sixty-three subsites of 20 X 20m were marked in 71 plantations from southern, central and northern regions of Kerala for assaying site and tree parameters. One soil sample was taken from 0-20cm depth in each of the 163 subsites and five dominant trees around the soil sample were selected for top height and girth measurements. The soil samples were analysed for gravel, sand, silt and clay separates, pH, organic carbon, exchange acidity and exchangeable bases.

Elevation of plantations varies from 25-850m with most falling in the 25-150m range. Majority of the subsites are well drained and all have good undergrowth. While 13 subsites have pure stands, others are mixed either with teak or Ailanthus. Correlation coefficient for dbh vs height is 0.87 (n=163) which indicates that the linear growth is not spindly. The correlation coefficients for height vs age and dbh vs age are poor (0.38 and 0.40) suggesting suppression of height and diameter growth. For comparative purposes, height data were transformed to 25 years and the midpoint between maximum and minimum height was taken as the cut-off height (15m) to differentiate stunted and nonstunted stands. Height varies from 6.7 to 21.3m and it declines towards north. Mean differences of soil parameters in stunted and nonstunted plantations are significant for all except sand and organic carbon in southern region, nonsignificant for all parameters in central region and nonsignificant for all except gravel and organic carbon in northern region.

Though the monsoonal climate in Kerala is congenial to Bombax, current study reveals that plantations in central and northern regions do not gain as much height as those in southern region. Stunted and nonstunted stands occur contiguously on subsites with similar physiographic features and above 750m elevation height growth is slow. Teak mixing with Bombax does not seem to have any effect on Bombax height while Ailanthus mixing may have an influence. Bombax comes up well in the sandy loam soils of southern but not central region, while stunted plantations of northern region have more silt +clay. The inconsistent trends of mean differences for soil parameters in stunted and nonstunted plantations suggest no clear-cut relationships between tree height and various soil parameters. The feasibility of planting Bombax in central and northern regions where it does not reach sufficient height needs appraisal.

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Key words : site factors, soil factors, Bombax plantations, Bombax stunting.

INTRODUCTION

Bombax ceiba L. (Bombax) plantations were raised in Kerala since 1952 as per Central Forestry Boards policy for formation of softwood plantations to meet match-wood requirements (Asari 1960). As noted in Working Plan Reports, Bombax does not attain good height by the rotation age of 25 years in many plantations (Asari '1960, George 1955, Karunakaran 1970, Nair 1959). The slow height growth may be due to ciimatic, physiographic, biotic and soil factors which constitute the environ-ment (site) of tree stand. This project, influence of site factors in Bombax plantations , was taken up to ascertain whether stunting is due to the site factors, especially soil.

REVIEW OF LITERATURE

Bombax occurs commonly in the semievergreen and moist deciduous forests upto an elevation of 1200m. It prefers moist tropical climate and thrives best in sites where a rainfall of 750-4000 mm is well distributed. The tree comes up well in deep sandy loam soils and it attains maximum growth in the alluvial soils of the valleys (Venkataramany 1968). In southern parts of Kerala, especially Thenmala region, Bombax is one of the dominant trees of natural forests (Asari 1960). Although an indigenous and dominant tree in the natural forest, raising Bombax in plantation is beset with problems due to its silvicultural characteristics. It is a strong light demander and fast grower. Due to its horizontal branching, a wide spacing is necessary which is not economical and in pure stand such spacing coupled with poor canopy expose soil. Hence mixed plantations of Bombax with teak and Ailanthus are formed. The literature is scanty regarding investigations on influence of site factors in Bombax plantations.

MATERIALS AND METHODS

Seventy-one Bombax plantations were selected from Thenmala, Punalur and Ranni Divisions in the southern, Kothamangalam, Chalakkudi, Trichur and Palghat Divisions in the central, and Nilambur Kozhikkode and Wynad Divisions in the northern regions (Fig. 1). In each plantation one to several subsites of 20 X 20m were marked for assaying site and tree parameters (Table 1). One soil sample was taken from 0-20cm depth in each of the 163 subsites. Five dominant trees around each soil sample were selected for top height and girth (gbh) measurements and the tree data were pooled. In most of the subsites soil depth was not a limiting factor for Bombax growth as indicated by field observations, good growth of the associated species and the lushy undergrowth. Therefore, soil samples below 20 cm were not taken for this study.

The soil samples were air-dried and passed through 2-mm sieve. Gravel (>2 mm), sand (0.02-2 mm), silt (0.002-0.02 mm) and clay (<0.002 mm) separates, pH in soil-water suspension (1 : 2 ratio), organic carbon, exchange acidity (exchangeable hydrogen + aluminium) and exchangeable bases (principally calcium, magnesium, ,potassium and sodium) were done according to procedures in Methods of Soil Analysis and Soil Chemical Analysis (ASA 1965, Jackson 1958). Cation exchange capacity (CEC) is the summation of exchange acidity and exchangeable bases and base saturation is the proportion of exchangeable bases.

RESULTS

Site parameters

Elevation of plantations varies from 25 to 850m With majority falling in the 25–150m range (Table 1). Out of the 71 plantations, Murukkappanchal, Amethotti, and Kurichiad are pure stands whereas others are mixed with teak or Ailanthus. Walayar, Kartikkulam, Athirakkuzhi, Panniyode and Velumpth stands occur as mixtures with Ailanthus and the rest are mixed with teak. Teak had been felled from the Kulathuppuzha and Pailivasal plantations. Excepting the poorly drained Vattakkarlkkam, Manalar, Kariem,-Muriem Eengar and Kanjirakkadav subsites all are well drained. Good undergrawth of ***Chromolaena odorata*** (Eupatorium) occurs in all the plantations.

Tree parameters

Top height and diameter (dbh) as of 1981 are presented in Table 1. The correlation coefficient for dbh vs height is 0.87 (n =163) which is significant at 1% level. This indicates that there is good relationship between the two tree parameters and the linear growth is not spindly The correlation coefficients for height vs age as well as dbh vs age are poor (0.38 and 0.40) suggesting suppression of height and diameter growth.

As the plantation age varies from 7-29 years, the height measurements have to be brought to a reference age for comparative purpose. Wealth of India data for Bombax as well as the Working Plan Reports for Thenmala, Punalur and Trichur (Asari 1960, George 1955, Mahendru 1932, WOI 1972) reveal that under favourable conditions trees of 21m height and 1. 8m girth (56cm dbh) are obtainable in 25-30 years. Three height vs age curves were drawn, one for lower points, second for the 'midpoints and third for the upper points (Fig. 2). Using these curves, the height data were transformed to rotation age of 25 years. The midpoint between maximum and minimum height was used to compute the cut-off height (15 m) to differentiate stunted and nonstunted stands (Table 2).

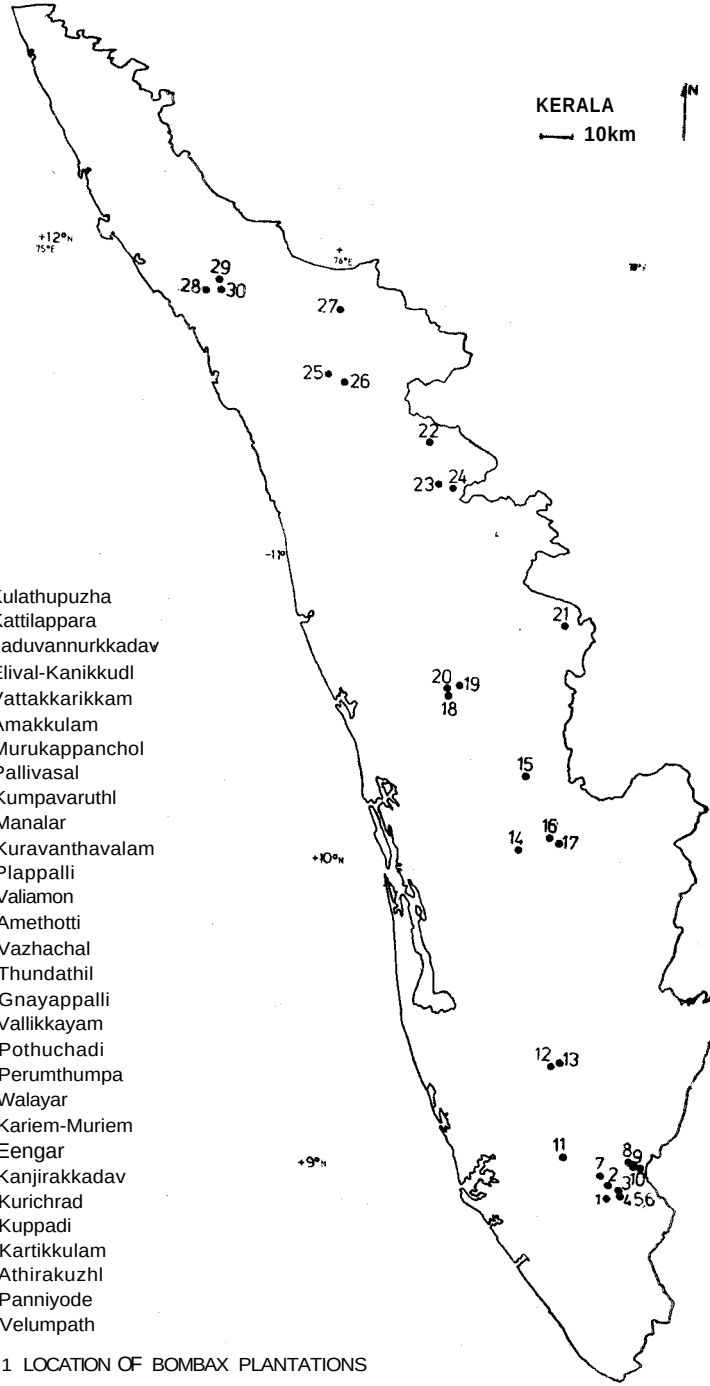

Fig 1 LOCATION OF BOMBAX PLANTATIONS

Table 1, Site and tree parameters in Bombax plantations

Plantation		Division	Site parameters	No. of sub-sites	Tree parameters: Height in 1981 (m)	Tree parameters: Dbh in 1981 (cm)
1		2	3	4	5	6
Kulathuppuzha	1959	Thenmala	150m, poorly drained, good undergrowth,	2	6.5	12.5
	1960		teak felled	2	8.3	15.2
Kattilappara	1958	Thenmala	150m, well drained,	3	11.1	21.7
	1960		good undergrowth,	2	11.2	24.6
	1966		mixed with teak	2	12.4	27.5
	1968		"	1	12.9	27.4
Naduvannurkkadav	1961	Thenmala	150m, well drained, good undergrowth, mixed with teak	2	9.8	22.0
Elival-Kanikkudi	1969	Thenmala	150m, well drained, good undergrowth, mixed with teak	2	13.8	17.9
Vattakkarikkam	1962	Thenmala	150m, poorly drained, good undergrowth, mixed with teak	3	7.8	17.9
Amakkulam	1963	Thenmala	150m, well drained,	2	8.6	16.2
	1964		good undergrowth,	3	11.3	16.7
	1965		mixed with teak	2	7.6	15.0
	1967			2	11.8	23.0

1		2	3	4	5	6
Murukappanchal	1952	Thenmala	200m, well drained, good undergrowth, pure stand	5	19.5	45.0
Pallivasal	1960	Thenmala	100m, well drained,	1	16.1	26.6
	1961		medium undergrowth,	2	17.7	33.2
	1964		teak felled	2	**14.5**	25.5
	1965			3	19.6	46.2
Kumpavaruthi	1958	Thenmala	100m, well drained, good undergrowth, mixed with teak	3	17.0	34.7
Manalar	1966	Thenmala	150m, poorly drained,	**2**	18.6	28.2
	1967		good undergrowth, mixed with teak	**1**	18.2	27.0
Kuravanthavalam	1959	Punalur	50m, well drained,	1	8.0	16.2
	1961		good undergrowth,	2	8.0	15.7
	1962'		mixed with teak	2	6.9	19.6
	1964			**4**	9.8	20.0
	1965			2	10.5	**22.7**
Plappalli	1962	Ranni	325-350m, well drained:	**2**	11.2	24.2
	1966		good undergrowth,	**1**	13.6	29.9
	1967a		mixed with teak	**1**	9.0	18.0
	1967b			**1**	13.9	36.9
Valiamon	1959	Ranni	100m, well drained, good undergrowth, mixed with teak	6	9.2	29.0
Amethotti	1974	Kothamangalam	**75m,** well drained, good undergrowth, pure stand	5	9.2	20.3

Vazhachal	1956 1957 1958 1959a 1959b 1961 1962 1973	Chakkkkkudi	150-350m weli drained, good ongergrowth, mixed with teak	1 1 1 1 I. 1 1 1	18.4 9.7 10.7 14.3 20.0 10.5 10.7 10.7	33.0 24.8 14.0 14.3 23.8 22.6 26.8 16.2
Thundathil	1956a 1956b 1957 1959	Chalakkudi	25m, well drained, good undergrowth mixed with teak	5 4 2 2	11.3 16.4 11.4 16.7	20.1 20.2 25.2 **29.6**
Gnayappalli	1966a 1966b	Chalakkudi	25m, well drained, good undergrowth, mixed with teak	8 6	10.2 13.3	15.8 25.0
Vallikkayam	1964a 1964b	Trichur	50m, well drained, good undergrowth, mixed with teak	2 1	11.4 13.4	**26.7** 25.2
Pothuchadi	1963a 1963b	Trichur	50m, well drained, good undergrowth, mixed with teak	1 2	13.2 16.7	31.8 29.6
Perumthumpa	1961a 1967b 1969	Trichur	150m, well drained, good undergrowth, mixed with teak	1 2 2	10.8 17.0 15.6	19.4 28,6 25.3
Walayar	1961	Palghat	225m, well drained, good undergrowth, mixed with teak and Ailanthus	2	9.7	31.0

1	2	3	4	5	6
Kariem – Muriem	1973	Nilambur	100m, poorly drained, 2 good undergrowth, mixed with teak	10.7	21.4
Eengar	1965	Nilambur	50m, poorly drained, 1	7.3	15.0
	1968		good undergrowth, 3. mixed with teak	10.9	20.2
Kanjirakkadav	1966	Nilambur	100m, poorly drained, 1 good undergrowth, mixed with teak	9.7	29.8
Kurichiad	1957	Kozhikkode	825m, well drained, 3 good undergrowth, pure stand	10.4	20.7
Kuppadi	1955a	Kozhikkode	850m, well drained, 3	12.2	24.7
	1955b		good undergrowth, 1 mixed with teak	15.7	24.0
Kartikkulam	1957	Wynad	750m, well drained, 3	8.9	14.5
	1960		good Undergrowth, 1	8.0	19.2
	1961		mixed with teak and 1	8.6	14.6
	1963a		other species 1	10.9	18.4
	1963b		1	14.0	78.0
Athirakkuzhi	1974	Wynad	100m, well drained 8 good undergrowth, mixed with Ailanthus	5.4	10.7
Panniyode	1955	Wynad	100m, well drained, 2	12.0	19.8
	1956		good undergrowth, 4 mixed with Ailanthus	11.4	16.3
Velumpath	1970	Wynad	75-100m, well drained, 4	6.4	12.6
	1974		good undergrowth, mixed 2 with Ailanthus	6.0	12.0

Height varies from 6.7m in Kulathuppuzha 1959 to 21.3m in Pallivasal 1965 plantations. Murukappanchal, Pallivasal, Manalar, Vazhachal 1959b and Perumthumpa 1967b plantations have good height growth. The dbh data support this observation in case of Murukappanchal, Manalar and Pallivasal stands. As observed in the Working Plan Reports (Asari 1960, Nair 1969) Bombax stands in some of the subsites in Thenmala Division attain good height and diameter.

Soil parameters

Bombax plantations in southern region: Kulathuppuzha, Kattilappara, Naduvannurkkadav, Elival-Kanikkudi, Vattakkarikkam, Amakkulam, Murukappanchal, Pallivasal, Kumpavaruthi, Manalar, Kuravanthavalam, Palappalli and Valiamon are the plantations in this region (Table 2). Murukappanchal 1952 and Pallivasal 1965 stands are good in comparison with WOI and Working Plan Report data (Asari 1960, WOI 1972). Pallivasal 1960, 1961, 1964, Kumpavaruthi 1958 and Manalar 1966, 1967 stands are also good in height growth. Mean differences for the 18 stunted and 13 nonstunted plantations are significant for gravel, silt, clay, pH, exchange acidity, exchangeable bases, CEC and base saturation (Table **3).** The data for Palappalli stunted and nonstunted plantations, 1976a and 1976b, do not show any definite trend in similarities or dissimilarities of soil properties.

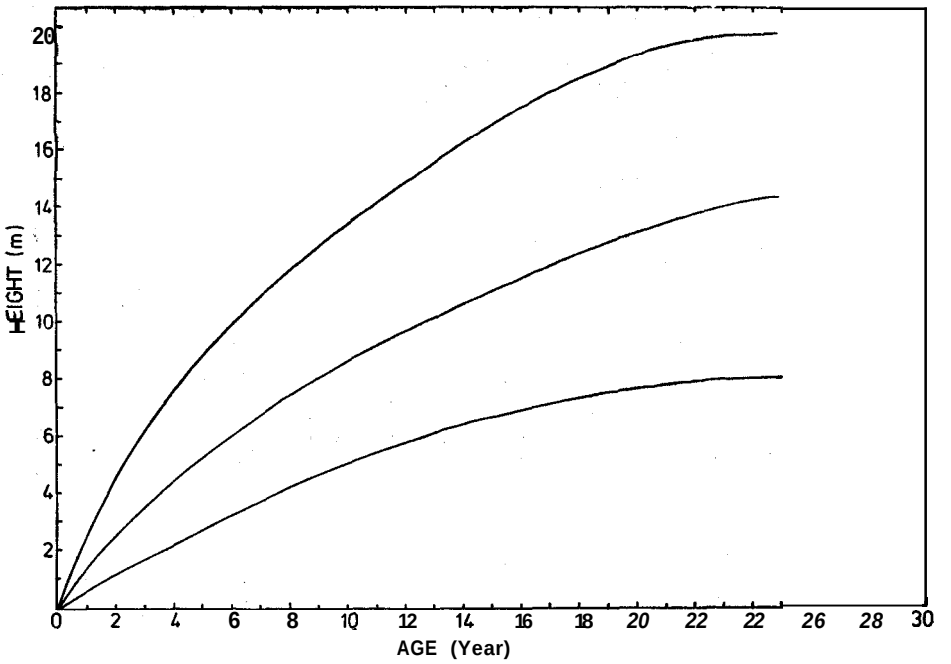

Fig.2. BOMBAX HEIGHT vs AGE CURVES

Table 2. Soil parameters in Bombax plantations

Plantation		Height at 25 years (m)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	pH	Organic carbon %	Exchange acidity (me%)	Exchangeable bases (me%)	CE	Base saturation (%)
1		2	3	4	5	6	7	8	9	10	11	12
Kulathuppuzha	1959	6.7	34	81	6	13	5.3	1.97	6.6	10.0	16.6	60
	1960	8.7	48	81	6	13	5.4	2.19	6.8	11.0	17.8	62
Kattilappara	1958	11.3	17	71	12	17	5.4	1.85	8.8	12.0	20.8	58
	1960	11.5	6	79	10	11	5.6	1.21	4.3	8.4	12.7	66
	1966	15.2	24	79	11	10	6.2	1.46	3.0	14.6	17.6	83
	1968	16.7	8	73	15	12	5.4	2.24	9.1	13.7	22.8	60
Naduvannurkkadav	1961	11.0	6	80	8	12	5.8	0.94	4.1	9.3	13.4	70
Elival–Kanikkudi	1969	18.6	25	80	9	.ll	g.6	2.42	8.5	10.1	18.6	54
Vattakkarikkam	1962	8.3	39	81	7	12	5.7	2.17	6.8	11.2	18.0	62
Amakkulam	1963	10.0	50	84	5	11	5.6	1.23	4.5	5.4	9.9	55
	1964	12.8	33	75	10	15	5.6	1.63	6.0	9.2	15.2	61
	1965	8.8	45	80	9	11	5.6	1.24	4.3	6.7	11.0	61
	1967	14.7	9	82	7	11	5.7	.0.72	3.3	6.1	9.4	65
Murukappanchal	1952	19.4	9	78	11	11	5.6	1.48	3.7	14.4	18.1	80

1		2	3	4	5	6	7	8	9	10	11	12
Pallivasal	1960	20.1	15	75	13	12	6.3	1.38	2.7	12.8	15.5	83
	1961	19.3	12	78	12	10	7.3	2.12	4.0	29.0	33.0	88
	1964	16.3	8	78	12	10	6.3	1.55	2.9	14.2	17.1	83
	1965	21.3	1	82	10	8	6.4	1.21	4.0	22.0	26.0	85
Kumpavaruthi	1958	17.1	6	78	11	11	6.4	1.64	2.7	19.2	21.9	88
Manalar	1966	21.2	4	76	12	12	6.4	1.62	2.5	18.4	20.9	88
	1967	20.7	10	75	11	14	6.2	0.90	3.1	10.0	13.1	76
Kuravanthavalam	1959	8.3	20	74	12	14	4.9	1.34	7.9	10.9	18.8	58
	1961	8.3	15	75	13	14	5.4	1.78	7.3	7.0	14.3	49
	1962	7.4	8	76	11	13	5.6	1.60	5.6	9.2	14.8	62
	1964	11.0	9	77	12	11	5.5	1.92	7.3	14.9	22.2	67
	1965	13.7	31	77	12	11	5.5	1.74	6.5	10.3	17.4	63
Plappalli	1962	12.4	13	80	9	11	5.6	1.54	3.8	10.1	13.9	72
	1966	16.5	16	74	16	10	5.3	1.76	6.2	9.9	16.1	62
	1967a	11.3	4	76	10	14	4.9	1.91	8.5	5.8	11.3	41
	1967b	17.2	8	76	14	10	4.7	1.75	8.8	6.9	15.7	44
Valiamon	1959	9.4	15	76	11	13	5.2	1.93	9.1	12.2	21.3	57
Amethotti	1974	17.2	13	81	10	9	5.5	1.35	4.9	7.5	12.4	61

1		2	3	4	5	6	7	8	9	10	11	12
Vazhachal	1956	10.4	4	83	9	8	5.5	1.10	4.8	6.6	11.4	58
	1957	9.9	3	78	12	10	6.1	1.67	4.5	12.0	16.5	73
	1958	10.9	2	74	14	12	5.9	1.99	4.9	14.8	19.7	75
	1959a	13.3	14	77	12	11	6.0	2.40	4.9	18.6	23.5	79
	1959b	20.1	8	82	8	10	5.9	1.65	4.9	8.8	13.7	64
	1961	11.1	3	80	12	8	5.5	1.09	5.5	12.0	17.5	69
	1962	11.4	20	84	8	8	5.4	1.75	4.8	6.0	10.8	56
	1973	18.4	23	81	9	10	5.8	1.66	5.6	10.4	16.0	65
Thundathil	1956a	11.8	14	81	9	10	5.2	1.91	7.6	6.5	14.1	46
	1956b	16.4	30	78	10	12	5.1	1.35	6.1	5.0	11.1	45
	1957	11.6	21	80	10	10	5.8	1.28	3.7	8.2	11.9	69
	1959	16.8	6	80	10	10	5.5	1.58	6.4	10.6	17.0	62
Gnayappalli	1966a	12.8	10	78	11	11	5.7	2.49	6.8	13.6	20.4	67
	1966b	16.2	17	80	10	10	3.5	1.93	5.8	8.9	14.7	61
Vallikkayam	1964a	13.0	12	79	11	10	6.0	2.57	6.8	18.6	25.4	73
	1964b	15.1	5	74	14	12	5.7	2.51	7.6	15.9	23.5	68
Pothuchadi	1963a	14.4	10	78	11	11	5.7.	2.13	7.6	14.2	21.8	65
	1963b	18.0	9	77	11	12	5.8	2.30	8.1	19.7	27.8	71
Perumthumpa	1967a	13.4	20	88	6	6	6.2	1.52	3.9	14.7	18.6	79
	1967b	20.1	6	81	10	9	6.0	1,60	4.6	15.1	19.7	77
	1969	19.6	5	81	10	9	5.9	1.15	4.1	11.6	15.7	74

1		2	3	4	5	6	7	8	9	10	11	12
Walayar	1961	10.2	1	80	10	10	6.4	1.14	2.3	16.0	18.3	89
Kariem–Muriem	1973	18.4	2	83	8	9	5.8	1.13	3.5	9.2	12.7	72
Eengar	1965	8.5	40	85	9	6	6.1	1.30	3.0	10.5	13.5	78
	1968	11.1	4	86	5	9	5.7	0.97	3.2	8.4	11.6	72
Kanjirakkadav	1966	12.3	13	82	8	10	6.0	1.22	3.1	12.8	15.9	81
Kurichiad	1957	10.6	2	76	12	12	5.5	1.46	4.5	9.1	13.6	67
Kuppadi	1955a	12.2	1	77	12	11	5.7	3.37	4.3	9.7	14.0	69
	1955b	15.7	1	81	10	9	5.6	1.10	3.7	7.6	11.3	67
Kartikkulam	1957	9.1	15	69	14	17	5.4	1.84	5.4	11.8	17.2	69
	1960	8.4	31	66	16	18	5.8	1.54	3.8	13.7	17.5	78
	1961	9.1	27	66	18	16	5.6.	2.00	6.9	15.1	22.0	69
	1963a	12.0	1	71	17	12	5.6	1.83	7.3	9.4	16.7	56
	1963b	15.3	2	70	16	14	5.8	1.47	3.8	12.1	15.9	76
Athirakkuzhi	1974	11.2	18	71	15	14	5.3	2.08	6.9	12.4	19.3	64
Panniyode	1955	12.0	10	69	15	16	5.0	2.03	8.6	10.3	18.9	54
	1956	11.4	25	67	14	19	5.4	1.97	6.3	13.1	19.4	68
Velumpath	1970	9.6	51	75	11	14	5.0	1.97	8.8	11.7	20.5	57
	€974	12.0	22	68	14	18	5.2	1.86	6.6	11.7	18.3	64

Table 3. Comparison of tree height and soil parameters in stunted and nonstunted Bombax plantations of southern region

Parameter	Stunted		Nonstunted		't' test
	mean	± sd	mean	± sd	
Number of plantations (n)	18		13		
Height at 25 years (m)l	10.3	2.2	18.4	2.0	**
Gravel (%)	22	16	11	7	•
Sand (%)	78	3	77	2	ns
Silt (%)	9	2	13	2	**
Clay (%)	13	2	10	2	**
pH	5.5	0.3	6.0	0.7	*
Organic carbon (%)	1.60	0.41	1.60	0.35	ns
Exchange acidity (me %)	6.2	1.0	4.7	2.5	*
Exchangeable bases (me %)	9.5	2.6	15.0	6.0	**
CEC (me %)	15.7	3.8	19.7	5.3	*
Base saturation (%)	60	7	75	i5	**

ns nonsignificant ; * , ** = significant at 5 and 1% level.

Table 4. Comparison of tree height and soil parameters in stunted and nonstunted Bombax plantations of central region

Parameter	Stunted		Nonstunted		't' test
	mean	±sd	mean	±sd	
Number of plantations (n)	13		10		
Height at 25 years (m)	11.9	1.5	17.8	1.7	**
Gravel (%)	10	6	12	9	ns
Sand (%)	80	4	79	8	ns
Silt (%)	10	2	10	2	ns
Clay (%)	10	2	11	1	ns
pH	5.8	0.3	5.7	0.3	ns
Organic carbon (%)	1.77	0.53	1.71	0.43	ns
Exchange acidity (me %)	5.2	1.6	5.8	1.3	ns
Exchangeable bases (me %)	12.4	4.4	11.3	4.4	ns
CEC (me %)	17.6	4.6	17.1	5.2	ns
Base saturation (%)	69	11	65	9	ns

ns = nonsignificant; ** = significant at 1% level

Table **5.** Comparison of tree height and soil parameters in stunted and nonstunted Bombax plantations of northern region

Parameter	Stunted		Nonstunted		't' test
	mean	±sd	mean	±sd	
Number of plantations (n)	14		3		
Height at 25 years (m)	10.9	1.7	16.5	1.7	**
Gravel (%)	19	15	2	1	**
Sand (%)	73	7	78	7	ns
Silt (%)	13	4	11	4	ns
Clay (%)	14	4	11	3	ns
pH	5.5	0.3	5.7	0.1	ns
Organic carbon (%)	1.67	0.36	1 23	0.21	ns
Exchange acidity (me %)	5.6	2.0	3.6	0 2	ns
Exchangeable bases (me %)	11.4	2.1	9.6	2 3	ns
CEC (me %)	17 0	3.0	13.2	2.3	ns
Base saturation (%)	67	7	72	4	ns

ns = nonsignificant; ** = significant at 1% level,

Bombax plantations in central region: Various plantations are Amethotti, Vazhachal Thundathil, Gnayappalli, Vallikkayam, Pothuchadi. Perumthumpa and Walayar (Table 2). Thirteen of them are stunted and ten nonstunted. Compared to the southern plantations height is less and only in three cases it approaches 20m: Vazhachal **1959b,** Perumthumpa **1967b** and **1969.** Mean differences are nonsignificant for all the soil parameters (Table **4).** Vazhachal **1959,** Thundathil **1956,** Gnayappalli **1966,** Vallikkayam **1964,** Pothuchadi **1963** and Perumthumpa **1967** data show more similarities than dissimilarities for soil properties of stunted and nonstunted stands.

Bombax plantations in northern region: Kariem-Muriem, Eengar, Kanjirakkadav, Kurichiad, Kuppadi, Kartikkulam, Athirakkuzhi, Panniyode and Velumpath are the plantations in this region (Table 2). Fourteen of the plantations are stunted and three nonstunted. The height growth is not as good as in south or central regions and no stand obtains a height of 20m in 25 years. Mean differences are significant for gravel and exchange acidity and nonsignificant for all other parameters (Table **5).** Stunted and nonstunted soil data for Kuppadi **1955** and Kartikkulam **1963** are not much different from each other.

DISCUSSION

Climatic factors

Climatic factors such as temperature, rainfall and length of dry season will have an effect on Bombax growth. Though the monsoonal climate in Kerala is congenial to Bombax, local variations in climatic patterns exist due to elevation and other topographic differences. Generally, regions south of Trichur have 3-4 dry months (<60 mm rainfall in a month) whereas northern regions have 4–5 dry months (KSLUB 1975) and how far this difference in rainfall distribution affects Bombax growth requires verification. The present data reveal that plantations in the central and northern regions do not reach as much height as the southern plantations.

Physiographic factors

Elevations in plantations are around 25-150*m* and only three plantations are located above 750m. Though Bombax can thrive well upto 1200m (Venkataramany 1968), there is an indication in the current study that its growth is slow above 750m. Another observation is that on subsites with similar elevations both stunted and nonstunted stands occur. Slope gradient, slope position and nature of slope have influence on tree growth and in sampling, every effort was made to take soil sample from a subsite with similar topographic variables. In the case of Plappalli, Vazhachal, Thundathil, Gnayappalli, Vallikkayam, Pothuchadi, Perumthumpa, Kuppadi and Kartikkulam plantations of similar age the physiographic factors are the same for stunted and nonstunted stands. Drainage has an effect in that on poorly drained sites, Bombax does not come up well (Venkataramany 1968). 'While 150 subsites are well drained, 13 are of poor drainage. Both stunted and nonstunted stands occur on subsites with similar drainage pattern and the data do not reveal any predominating influence of drainage on the height growth Bombax.

Biotic factors

The possibility of whether Bombax plantations are mixtures of ***B. ceiba*** and ***B. insignis*** was looked into. Based on the observations in 15 subsites of Vazhachal, Pothuchadi, Vallikkayam and Perumthumpa, Bombax plantations are composed predominantly of ***B. ceiba*** though a few ***B. insignis*** trees are spotted at random.

Another biotic factor is provenance variation and its effect on height growth. As the plantations stretch aboyt 300 kilometres from Thenmala to Wynad Divisions, provenance variation was kept to minimum by stratified sampling from southern central and northern regions. In Thenmala Division, 23 subsites are stunted and 24 nonstunted, in Chalakkudi 17 are stunted and 18 nonstunted and in Wynad.26 are stunted and one nonstunted. In each of these Divisions, it is unlikely that provenances of different origin could have been used. The question of associated species with Bombax was also looked into. It is noted that out of the 29 subsites where Bombax is mixed with Ailanthus, 28 are stunted. Literature gives the impression that teak may not be mixkd with Bombax (Champion 1932). However, in the present study some of the best Bombax stands are seen in Bombax-teak mixtures in Thenmala Division. Also, there is no indication that pure stands of Bombax are superior or inferior to Bombax-teak stands.

Undergrowth may have an effect on the growth of main species in plantations. All the Bombax platations of this study have good growth of Eupatorium and the effect of its density on tree height was not studied. A report from Assam indicates that undergrowth has suppressed the Bombax growth in plantations (Prasad 1942). in the present study, both stunted and nonstunted plantations have good under–growth

Soil factors

Though the mean differences for various soil parameters except sand and organic carbon are significant in southern region, the same trend is not seen in central and northern regions. All the mean differences are nonsignificant in the central region whereas for northern region those excepting gravel and organic carbon are non-significant. In general the stunted plantations tend to have comparatively more gravel and exchange acidity in the southern and northern regions.

It is noted in Working Plan Reports that Bombax comes up well in well-drained and deep sandy loam soils, The data of current study also indicate that Bombax fares well in sandy loam soils of the southern region, especially Thenmala Division. One stand, Pallivasal 1965 has 19.6m height and 46.2cm dbh at 16 years and there are several stands in this Division with 18m or more height at 25 years. In the central. region, though most of the subsites have sandy loam soils, Bombax does not attain as much height as in southern region. Thirty-four out of 41 subsites in the northern region have invariably more silt +clay and these have generally stunted Bombax.

CONCLUSION

Though the monsoonal climate in Kerala is congenial to Bombax, this study reveals that plantations in central and northern regions do not gain as much height as those in southern region. Stunted and nonstunted stands occur contiguously on subsites with similar physiographic features and above 750m elevation, height growth is slow. Teak mixing with Bombax does not seem to have any effect on Bombax height while Ailanthus mixing may have an influence. Bombax comes up well in the sandy loam soils of southern but not central region, while stunted plantations of northern region have more silt + clay. The inconsistent trends of mean differences for soil parameters in stunted and nonstunted plantations suggest no clear-cut relationships between tree height and various soil parameters. The feasibility of planting Bombax in central and northern regions where it does not attain sufficient height needs evaluation.

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